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Assessing post-harvest losses in value chain of wheat farmers in district Shikarpur, Sindh

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Abstract

Wheat plays a vital role in ensuring food security and economic livelihood in Pakistan, yet significant post-harvest and value chain losses hinder its productivity, particularly in District Shikarpur, Sindh. This study was conducted to investigate the extent, causes, and consequences of these losses along the wheat value chain and to propose practical interventions for mitigation. The research was carried out in two selected talukas of Shikarpur District, covering four Union Councils with a sample of 120 wheat farmers (30 from each UC). Data were collected through structured personal interviews using the KoboCollect tool for real-time data recording. Findings revealed a series of interconnected challenges across the value chain. In the pre-harvest phase, 77.5% of farmers reported a lack of modern machinery for land preparation, while 75.83% faced high costs of certified seed, and 80.83% were burdened by the high cost of fertilizer. Water shortages (55.83%) and poor access to pesticide application equipment (65.83%) further constrained production. During the harvesting stage, delays (43.33%), labor shortages (53.33%), and high harvesting costs (57.5%) were commonly cited. Post-harvest losses were primarily attributed to inefficient threshing machinery (85%), use of low-quality storage bags (42.5%), and rodent attacks during storage (70%). Additionally, 63.33% of respondents lacked access to credit, and 74.17% reported insufficient farmer training factors that cut across all stages of the value chain and significantly limited farmers' capacity to adopt improved practices. Most respondents were middle-aged, married males with modest educational backgrounds, managing small to medium-sized farms under tenancy arrangements. Mono-cropping dominated the region, and while agriculture remained the primary income source, many households also depended on livestock and wage labor. The study underscores the urgent need for investment in farmer education, affordable and timely access to inputs, modern machinery, and improved storage and transportation infrastructure. Targeted interventions at each stage of the wheat value chain can reduce post-harvest losses and enhance overall productivity and profitability in the region.

Keywords: Wheat value chain, post-harvest losses, food security, farmer livelihoods, Shikarpur District, Sindh, input constraints, harvesting challenges, storage losses

INTRODUCTION

Wheat (*Triticum aestivum L.*) is one of the most widely cultivated crops globally, serving as a staple food for millions. It is grown as a commercial crop due to its high economic returns, adaptability to temperate climates with short growing seasons, and ability to produce high-quality flour (Sikandar et al., 2024). Currently, wheat covers approximately 220 million hectares worldwide, with an annual production of about 778 million metric tons, contributing around 10% to agricultural value addition. Its significance continues to grow due to increasing food and nutritional demands driven

by population growth, with an average yield of 3.5 tons per hectare (Nyaupane et al., 2024). Wheat is a key staple in human nutrition, providing about 9–10% protein and 60–80% carbohydrates. Rich in protein, vitamins, and carbs, it supports food security and meets global nutritional needs (Kaleri et al., 2024). Wheat is the world's most widely consumed cereal and a cornerstone of food security. Increasing its production is vital to ensuring stable food supplies and reducing hunger. Based on growing seasons, wheat is classified as winter or spring wheat. From 1990 to 2021, global production rose from 592 to 788.6 million metric tons. Major producers include China, India, Russia, the U.S., Canada, the EU, Pakistan, Ukraine, Argentina, and Turkey (Ismail et al., 2024; Chohan et al., 2021). As the world's population continues to grow quickly, producing enough food has become a major challenge. By 2050, the global population is expected to reach 9.1 billion, which means food production will need to increase by about 70% to meet demand (Kumar & Kalita, 2017).

Table1.
Major wheat producing countries in the world in year 2024

Country	Production (thousand metric tons)
China	136,590
European Union	134,300
India	110,554
Russia	91,000
United States	49,314
Canada	33,824
Pakistan	28,000
Australia	25,500
Ukraine	23,400
Turkey	19,500

Source: (Statista, 2024)

Table 1 is showing that in 2024, China led the world in wheat production, harvesting 136.59 million metric tons. The European Union followed closely with 134.3 million metric tons, while India secured the third spot with 110.554 million metric tons. Russia ranked fourth, producing 91 million metric tons, and the United States came in fifth with 49.314 million metric tons. Canada also played a key role, yielding 33.824 million metric tons. Other major producers included Pakistan with 28 million metric tons and Australia with 25.5 million metric tons. Ukraine and Turkey completed the top ten, producing 23.4 million and 19.5 million metric tons, respectively. These numbers highlight the importance of these nations in global food production, as wheat remains a crucial staple in many diets worldwide (Statista, 2024).

Pakistan ranks as the seventh-largest wheat producer globally, with wheat being a vital food crop in the country. It is primarily cultivated in the irrigated regions of Punjab and Sindh during the Rabi season, making it the most important crop of this period and a staple food for many people (Kaleri et al., 2024; Manzoor et al., 2021). Wheat is the second-most consumed food crop in Pakistan, particularly in the northern and northwestern areas (Kaleri et al., 2024). Over the years, wheat production has shown an upward trend, increasing from 28,161 thousand metric tons in 2022-23 to 31,438 thousand metric tons in 2023-24 (GoP, 2024a). Pakistan contributes about 3.04% of the world's wheat while using 3.57% of the global wheat cultivation area, securing its position as the seventh-largest producer. Punjab produces the majority of the country's wheat at around 76%, followed by Sindh at 16%, Khyber Pakhtunkhwa at 5%, and Balochistan at 3% (Ismail et al., 2024). During the 2023–24 seasons, wheat cultivation expanded by 6.6% to 9.6 million hectares, while production rose 11.6% to

31.4 million tonnes. The government set the MSP at Rs 3,900 per 40 kg. Despite a December 2024 dry spell that may affect yields, favorable weather, adequate soil moisture, input availability, and wider sowing supported a strong harvest outlook. Wheat contributes 9.0% to agriculture and 2.2% to GDP (GoP, 2024a).

Table 2.
Wheat Production Trends in Pakistan (2014-2025)

Year	Area (1000 Acre)	Production (1000 Tons)	Yield (T/Acre)
2014/2015	22,741.95	25,979	1.14
2015/2016	22,754.30	25,086	1.10
2016/2017	22,804.72	25,633	1.13
2017/2018	22,173.44	26,674	1.20
2018/2019	21,743.29	25,076	1.15
2019/2020	21,450.86	24,349	1.14
2020/2021	21,762.71	25,248	1.16
2021/2022	22,658.37	27,464	1.21
2022/2023	22,185.78	26,209	1.18
2023/2024	22,326.78	28,161	1.26
2024/2025	24,058.17	31,583	1.31
5-year Average (2019/20 - 2023/24)	22,076.10	26,286	1.19
Percent Change From 5-Year Average (%)	22.24	20	0.40
Record	22,804.72	28,161	1.26
Record Year	2016/2017	2023/2024	2023/2024

Source: (USDA, 2025)

Table 2 presents the trends in wheat cultivation, production, and yield in Pakistan over the period from 2014 to 2025. The data highlights fluctuations in both areas under cultivation and production volumes across the years. The cultivated area peaked in 2016-2017 at 22.80 million acres, while the highest production was recorded in 2023-2024, reaching 28.16 million tons. Yield per acre also showed improvement over time, with the maximum yield of 1.26 tons per acre achieved in the same year. The most recent data for 2024-2025 reflects a notable rise in cultivated area, which expanded to 24.06 million acres, and a significant increase in production, reaching a record of 31.58 million tons. This marks a 22.24% increase in area and a 20% rise in production compared to the five-year average (2019-20 to 2023-24). Yield per acre also saw a positive change of 0.40 tons above the average. Overall, these figures indicate gradual improvements in both farming practices and productivity, particularly in the past few years (USDA, 2025).

Table 3.
Wheat Productions in Pakistan by Province (2014–2023) (Thousand Metric Tons)

YEAR	Punjab	Sindh	KPK	Balochistan
2014	19738.90	4002.10	1363.10	875.30
2015	19281.90	3672.20	1259.90	872.10
2016	19526.70	3834.60	1400.50	871.30
2017	20466.30	3910.40	1365.10	931.80
2018	19178.50	3639.50	1322.70	935.40
2019	18377.20	3778.90	1336.70	865.30
2020	19401.90	3850.00	1130.40	867.20
2021	20900.00	4043.17	1361.59	1159.33
2022	20032.00	3759.75	1380.92	1220.98
2023	21225.00	3940.17	1494.14	1516.23

Source: (PBS, 2024)

Table 3 indicates wheat production data (in thousand metric tons) for the four provinces of Pakistan, Punjab, Sindh, Khyber Pakhtunkhwa (KPK), and Balochistan

from 2014 to 2023. Punjab consistently recorded the highest wheat production among the provinces, with figures ranging from 18,377.20 thousand metric tons in 2019 to a peak of 21,225.00 thousand metric tons in 2023. Sindh follows as the second-largest wheat-producing province, with production fluctuating between 3,639.50 thousand metric tons in 2018 and 4,043.17 thousand metric tons in 2021. KPK and Balochistan exhibit relatively lower production levels, with KPK's output varying between 1,130.40 thousand metric tons in 2020 and 1,494.14 thousand metric tons in 2023, while Balochistan shows a general upward trend, reaching its highest production of 1,516.23 thousand metric tons in 2023. The data highlights fluctuations in wheat production across all provinces, influenced by various factors such as climatic conditions, agricultural practices, and government policies (PBS, 2024).

In the 2023-24 crop seasons, wheat production in Sindh exceeded 4.2 million metric tons. So far, the Food Department has procured 643,000 metric tons. The Sindh Government has set a target to purchase 900,000 metric tons at a rate of Rs. 4000 per 40 kilograms. To streamline the procurement process, 353 wheat procurement centers are planned to be set up across the province (APP, 2024).

The agricultural value chain comprises a sequence of connected activities that transform agricultural products from their initial production on farms to their final consumption. This chain involves several key stages, including input supply, cultivation, processing, marketing, and distribution. At each phase, value is added to the product through the efforts of different stakeholders, including farmers, input providers, traders, processors, retailers, and ultimately, consumers (Agrawal & Jain, 2024). Value chain approach is vital for adapting agriculture to rapid socio-economic changes in developing countries. The agri-food value chain covers all steps from production to consumption and the interactions among stakeholders (Liu et al., 2023). In wheat, losses occur from poor field management, delayed harvesting, or bird attacks, as well as during harvesting, transport, storage, and processing. Improving storage, handling, and processing can reduce waste and enhance global food security (Bartali et al., 2022).

Post-harvest losses in agriculture arise from harvesting to consumption due to traditional methods, poor handling, weather changes, weak infrastructure, and limited resources. In developing countries with low mechanization, high poverty, and inadequate market systems, these losses are especially severe reaching 50–60% for cereal grains. Major losses occur during drying, transport, and storage because of outdated practices and lack of awareness. Reducing post-harvest losses is vital for improving food security, alleviating poverty, and boosting incomes. Globally, about 11.3% of people (900 million) faced severe food insecurity in 2022 (FAO, 2023). In Pakistan, where agriculture underpins the economy, enhancing the sector particularly wheat production is crucial for food security and economic growth (Manzoor et al., 2021).

The issue of post-harvest losses in the wheat value chain is a significant concern for farmers in Pakistan, particularly in Sindh. Limited observed research exists on the extent and causes of these losses, especially in district Shikarpur. In this region, small, medium, and large-scale wheat farmers face various challenges related to storage, transportation, and market inefficiencies, which contribute to post-harvest losses. The primary objective of this study is to assess the magnitude of post-harvest losses in the wheat value chain and identify the key factors affecting them. By analyzing these challenges, this research aims to provide insights that can help improve post-harvest

management and enhance the overall efficiency of the wheat supply chain in the district.

- To examine socioeconomic characteristics of wheat growers in the study area
- To find out the issues in value chain of wheat growers in the study area
- To find out post-harvest losses of wheat and suggest policy measures

MATERIALS AND METHODS

Methodology

This study was carried out on the basis of primary data to be collected from the farmers of wheat cultivation in district Shikarpur province of Sindh. The research data was selected on the availability of wheat producers.

Study area

This research was carried out in the Shikarpur District of Sindh Province, Pakistan, which spans an area of 2,512 square kilometers. According to the 2023 census, the district had a total population of 1,386,330, with an average household size of 6.4 of this population; approximately 318,738 individuals lived in urban areas, while 1,067,592 resided in rural regions (GoP, 2024b). Located in the northern part of Sindh, Shikarpur plays a significant role in the province's agricultural sector (Chandio et al., 2018). The region experiences a semi-arid climate, presenting challenges in water management and agricultural productivity. Farming in the district is primarily carried out by smallholders, with wheat serving as the staple crop. This district was chosen for the study due to its crucial role in Pakistan's agribusiness sector and the distinct post-harvest difficulties encountered by its wheat farmers.

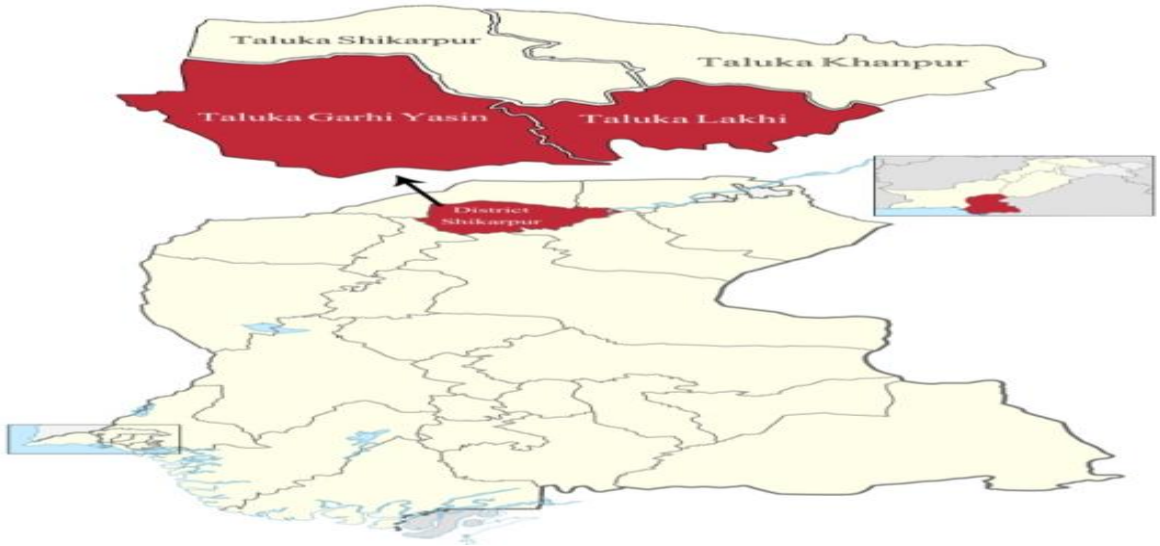

Figure 1.

Sampling size and sampling method

Due to time and financial constraints, the study was limited to the district of Shikarpur. To collect primary data on post-harvest losses in the wheat value chain, a total of 120 respondents were purposively selected from various villages across Shikarpur District, Sindh. The sample was evenly distributed across two Talukas: Garhi Yasin and Lakhi. In Taluka Garhi Yasin, two Union Councils (UCs) were selected, with 30 respondents from each UC. Within each UC, three villages were included, and 10 respondents were selected from each village. Similarly, in Taluka Lakhi, two UCs were selected, with

30 respondents from each. Each UC included three villages, from which 10 respondents were chosen per village. The sample size is based on a 95% confidence level and a 9.5% margin of error. Data was collected through personal interviews to gain detailed insights into post-harvest losses, and analyzed using Microsoft Excel and Kobo. This methodology is also used by Sekaran and Bougie (2016) and Yin (2017).

Table1.
Sample size of primary data

		UC	Respondent	Village	Frequency	Total
SHIKARPUR	Taluka Garhi Yasin	UC Amrot Sharif	30	Amrot Sharif	10	120
				Orangabad	10	
				Toor Band	10	
		UC Masti Khan	30	New Amrot	10	
				Shah Ali Ji Wandh	10	
				Village Nawab Dal	10	
	Taluka Lakhi	UC Ruk	30	Ruk	10	
				Rehan Khan Jamali	10	
				Muhammad Ali Kalhoro	10	
		UC Sherkot	30	Sherkot	10	
				Jamra	10	
				Atta Muhammad Khoso	10	

Questionnaire

The most critical aspect of the survey process was the development of well-structured questions. The questionnaire was specifically designed for wheat producers.

Percentage, average, standard deviation

The information gathered was analyzed in tabular form to allow easy comparisons. The data will be summarized in order to obtain meaningful results with the help of statistical instruments such as average, percentage, standard deviation. The formulas are as shown below

For percentage

It was determined using the formula below:

$$P = \frac{F}{N} * 100 \quad (1)$$

F = Sample frequency
N = Aggregate number of respondents

For average

Sum of all observation divided by total number of observation

$$\bar{X} = \frac{\sum \mathrm{xi}}{\mathrm{n}} \quad (2)$$

Where,
$\bar{X}$ = sample mean
$\sum xi$= sum of all observation
n = number of observation

Standard deviation

Formula of standard deviation is

$$SD = \frac{\sqrt{\sum (X - \bar{X})^2}}{\sqrt{n-1}} (3)$$

Where,
SD = sample standard deviation
$\sum$ = sum

$\bar{X}$ = sample mean
n = number of observations

The role of KoboCollect in processing and organizing data

KoboCollect was instrumental in data collection, capturing real-time responses directly from the field. The gathered data were automatically processed, including calculations of the mean, median, mode, standard deviation, percentage & frequencies. KoboCollect streamlined the organization of numerical responses, simplifying the application of statistical functions. Its integration enabled efficient computation of central tendency measures, ensuring a comprehensive and reliable analysis of farmers' perspectives. By leveraging KoboCollect, the study adopted a robust analytical approach, effectively pinpointing strengths and weaknesses within the value chain. This, in turn, supported targeted interventions aimed at improving farmer engagement and operational efficiency.

RESULTS

The study was conducted to assess post-harvest losses in the wheat value chain from the perspective of farmers in District Shikarpur, Sindh, Pakistan. Due to time and financial constraints, a total of 120 respondents were selected using a stratified sampling approach, with an equal distribution across two Talukas: Garhi Yasin and Lakhi. In each Taluka, two Union Councils (UCs) were chosen, with 30 respondents from each UC. Three villages were selected per UC, and 10 respondents were surveyed from each village. Data collection was carried out through personal interviews to gain in-depth insights into post-harvest losses, utilizing the KoboCollect tool to capture real-time responses directly from the field.

Table 2.
Demographic profile of respondents in the study area

Variable	Respondents Frequency 120	Percentage 100%
Gender		
Male	120	100
Female	0	0
Age		
20-35	33	27.5
36-50	51	42.5
51-65	26	21.7
66-80	10	8.3
Marital status		
Married	93	77.5
Unmarried	27	22.5

Table 1 presents the demographic characteristics of the 120 respondents surveyed for the study. All respondents were male (100%), indicating that wheat farming and post-harvest activities in the study area are predominantly managed by men. Regarding age distribution, the largest proportion of respondents (42.5%) were between 36 and 50 years old, followed by 27.5% aged 20–35, and 21.7% aged 51–65. Only a small percentage (8.3%) was above 65 years of age. In terms of marital status, the majority of respondents (77.5%) were married, while 22.5% were unmarried. These findings suggest that middle-aged, married men constitute the primary labor force engaged in wheat farming and its post-harvest processes in the study region.

Table 2 summarizes the respondents' educational qualifications, family structure, and household size. The data indicate that nearly half of the respondents (40.83%) had completed primary education, while 21.67% had attained matriculation, and 15.83%

had reached higher secondary education. A smaller proportion were graduates (6.67%), and 15% had no formal education, reflecting a generally modest educational background among the farming community. Regarding family structure, 55.83% of respondents lived in nuclear families, while 44.17% belonged to joint family systems. In terms of household size, the majority (45%) reported having 5–10 members per household, 25.83% had fewer than 5 members, and 22% had 11–20 members.

Table 3.
Educational background, family structure, and household size of respondents

Variable	Frequency (120)	Percentage (100%)
Education		
No formal education	18	15
Primary	49	40.83
Matriculation	26	21.67
Higher Secondary	19	15.83
Graduate	8	6.67
Family structure		
Nuclear family	67	55.83
Joint family	53	44.17
Household size		
< 5	31	25.83
5-10	54	45
11-20	27	22
> 20	8	6.67

Only 6.67% of respondents had households with more than 20 members. These results highlight that most respondents come from medium-sized, nuclear families with basic education levels, which may influence labor availability and decision-making in wheat post-harvest operations.

Table4.
Land ownership, farm size, and farming experience of respondents

Variable	Frequency (120)	Percentage (100%)
Land ownership status		
Owner	37	31
Tenant	61	51
Owner-Tenant	22	18
Farm size (Acres)		
< 5	37	30.83
5-10	66	55
11-20	13	10.83
> 20	4	3.33
Farming experience (Years)		
< 5	23	19.17
5-10	37	30.83
11-20	43	35.83
> 20	17	14.17

Table 3 outlines the respondents' land ownership status, farm size, and farming experience. The majority of respondents (51%) were tenants, followed by 31% who owned their land, and 18% who operated as both owners and tenants. This indicates that tenant farming is a prevalent practice in the study area. Regarding farm size, over half of the respondents (55%) cultivated between 5 and 10 acres, while 30.83% had farms smaller than 5 acres. A smaller proportion operated larger farms: 10.83% had between 11 and 20 acres, and only 3.33% had farms exceeding 20 acres. In terms of farming experience, most respondents (35.83%) reported 11–20 years of experience, followed by 30.83% with 5–10 years of experience. Around 19.17% were relatively new to farming with less than 5 years of experience, while 14.17% had extensive experience

spanning over 20 years. These findings suggest that the majority of wheat farmers are experienced cultivators managing small to medium-sized farms, with a significant reliance on tenancy arrangements.

Table 5.
Cropping patterns practiced by respondents

Variable	Cropping pattern Frequency (120)	Percentage (100%)
Mixed cropping	17	14.17
Mono cropping	94	78.33
Crop rotation	9	7.5

Table 4 illustrates the cropping patterns adopted by the respondents. The data show that mono cropping is the dominant practice, followed by 78.33% of respondents. Mixed cropping was reported by 14.17% of the farmers, while only 7.5% practiced crop rotation. These findings indicate a strong preference for mono cropping in the study area, which may have implications for soil fertility, pest management, and overall sustainability of wheat production.

Table 6.
Primary and secondary sources of income of respondents

Varaible	Sources of income Frequency (120)	Percentage (100%)
Primary source		
Agriculture	66	55
Daily Wages	23	19.17
Non-Agriculture employment	7	5.83
Livestock	13	10.85
Business	11	9.17
Secondary source		
Agriculture	37	30.83
Daily Wages	33	27.6
Non-Agriculture employment	3	2.5
Livestock	29	24.16
Business	3	2.5

Table 5 presents the primary and secondary income sources of the respondents. Agriculture emerged as the main source of livelihood for the majority (55%), highlighting its central role in sustaining rural households. Daily wages accounted for 19.17% of respondents' primary income, followed by livestock (10.85%), business (9.17%), and non-agriculture employment (5.83%). As for secondary income sources, agriculture remained significant (30.83%), but livestock also played a notable role (24.16%). Daily wages were reported by 27.6% of respondents as a secondary source, while non-agriculture employment and business were each reported by 2.5% of respondents. These results indicate that while agriculture is the dominant source of income, many respondents diversify their livelihoods with livestock rearing and wage labor to enhance economic stability.

Table 6 details the respondents' monthly income from primary and secondary sources, along with their household expenditure. The primary income ranged from a minimum of PKR=9,000 to a maximum of PKR=100,000, with an average monthly income of PK=40,508. Secondary income ranged between PKR=8,000 and PKR=70,000, averaging PKR=20,811. In terms of household expenditure, the minimum monthly spending reported was PKR=25,000, while the maximum reached PKR=120,000. Table 6 details the respondents' monthly income from primary and secondary sources,

along with their household expenditure. The primary income ranged from a minimum of PKR=9,000 to a maximum of PKR=100,000, with an average monthly income of PK=40,508. Secondary income ranged between PKR=8,000 and PKR=70,000, averaging PKR=20,811.

Table 7.
Monthly income and household expenditure of respondents

	Monthly income	
Variable	**Primary**	**Secondary**
Min	9000	8000
Max	100000	70000
Average	40508	20811
Monthly household expenditure		
Min	25000	
Max	120000	
Average	57795	

Table 6 details the respondents' monthly income from primary and secondary sources, along with their household expenditure. The primary income ranged from a minimum of PKR=9,000 to a maximum of PKR=100,000, with an average monthly income of PK=40,508. Secondary income ranged between PKR=8,000 and PKR=70,000, averaging PKR=20,811. In terms of household expenditure, the minimum monthly spending reported was PKR=25,000, while the maximum reached PKR=120,000. The average household expenditure stood at PKR=57,795 per month. These figures suggest that, although many respondents supplement their primary income with secondary sources, household expenditures are relatively high, which could impact their overall financial stability and investment capacity in farming activities.

Table 8.
Access to government/NGO support and debt status of respondents

	Government / NGO's support	
Variable	**Frequency (120)**	**Percentage (100%)**
Yes	63	52.5
No	57	47.5
Debt situation		
Yes	43	35.84
No	77	64.16

Table 7 highlights respondents' access to government or NGO support and their debt status. Slightly more than half of the respondents (52.5%) reported receiving some form of assistance from government agencies or NGOs, while 47.5% had not benefited from any such support. In terms of debt, 35.84% of respondents indicated that they were in debt, whereas the majority (64.16%) reported having no current debt. These findings suggest that although a significant portion of farmers receive institutional support, a notable minority continue to rely on borrowing, which could affect their financial resilience and capacity to invest in post-harvest improvements.

Table 8 outlines the various issues encountered by respondents within the wheat value chain. The most common challenge identified was the lack of access to credit or financing for inputs, reported by 63.33% of respondents. A significant percentage also highlighted issues related to the high cost of certified seed (75.83%) and the high cost of fertilizer (80.83%). Other notable challenges included the lack of modern machinery for land preparation (77.5%), a shortage of irrigation water (55.83%), and labor shortages for harvesting (53.33%). Furthermore, 65.83% of respondents reported lacking proper pesticide application equipment, while 74.17% indicated that they

had received inadequate farmer training. Additionally, many farmers faced issues with the high cost of harvesting services (57.5%) and the delay in sowing (40.83%).

Table 8.
Issues in the wheat value chain as reported by respondents

No.	Issues in value chain	Frequency (120)	Percentage (100%)
1.	Lack of access to credit or financing for inputs	76	63.33
2.	Lack of modern machinery for land preparation	93	77.5
3.	Poor fertility of land	44	36.67
4.	Poor quality of seed	57	47.5
5.	High cost of certified seed	91	75.83
6.	Delay in sowing	49	40.83
7.	Uneven sowing	23	19.17
8.	Poor germination of seed	45	37.5
9.	Water shortage	67	55.83
10.	High cost of irrigation	23	19.17
11.	Shortage of fertilizer	43	35.83
12.	High cost of fertilizer	97	80.83
13.	Lack of knowledge about proper fertilizer dosage	63	52.5
14.	Uneven application of fertilizer	17	14.17
15.	Poor-quality pesticides	53	44.17
16.	High cost of pesticides	77	64.17
17.	Lack of pesticide application equipment	79	65.83
18.	Delay in harvesting	52	43.33
19.	Labor shortage for harvesting	64	53.33
20.	High cost of harvesting services	69	57.5
21.	Lack of farmer training	89	74.17

These results reflect the multifaceted challenges faced by farmers in the wheat value chain, from input accessibility and affordability to issues with labor, machinery, and knowledge. The findings suggest that improving financial access, providing training and reducing input costs could significantly alleviate these bottlenecks and enhance productivity.

Table 9.
Post-harvest losses in the wheat value chain as reported by respondents

No.	Post harvest losses	Frequency (120)	Percentage (100%)
1.	Yield losses resulting from delayed harvesting	52	43.33
2.	Grain losses due to shattering at the time of harvest	61	50.83
3.	Physical damage to grains caused by mechanical harvesting	34	28.33
4.	Harvesting losses due to labor inefficiency	37	30.83
5.	Grain losses from animal grazing during the drying period	22	18.33
6.	Theft-related grain losses during drying	23	19.17
7.	Losses due to improper stacking or heaping of harvested crop	7	5.83
8.	Grain scattering and loss during the threshing process	19	15.83
9.	Inefficiency of threshing machinery leading to grain losses	102	85
10.	Threshing losses due to poor drying	17	14.17
11.	Grain loss due to the use of low-quality storage bags	51	42.5
12.	Grain damage from packaging failures	24	20

Table 9 provides insights into the various post-harvest losses experienced by respondents during wheat processing. The most significant loss occurred due to inefficiency in threshing machinery, which led to 85% of respondents reporting grain losses. Other common issues included grain losses resulting from delayed harvesting (43.33%), grain loss due to shattering during harvest (50.83%), and grain losses caused by the use of low-quality storage bags (42.5%). Physical damage to grains during

mechanical harvesting (28.33%) and harvesting losses due to labor inefficiency (30.83%) were also prominent challenges. Furthermore, losses during the drying period were significant, with 18.33% of respondents experiencing grain losses from animal grazing and 19.17% facing theft-related losses. Threshing losses due to poor drying (14.17%) and grain scattering during threshing (15.83%) were additional concerns. These results underscore the importance of improving threshing equipment, storage facilities, and post-harvest handling techniques to minimize losses and enhance the efficiency of the wheat value chain.

Table 10.
Additional post-harvest losses in the wheat value chain as reported by respondents

No.	Post harvest losses	Frequency (120)	Percentage (100%)
1.	Grain losses caused by rough and poor road conditions	47	39.17
2.	Weight reduction in stored grain over time	75	62.5
3.	Grain losses due to insect infestation	35	29.17
4.	Grain losses caused by rodent attacks	84	70.0
5.	Spillage losses during the transportation of grains	47	39.17
6.	Fungal/mold losses during long-term storage	63	52.5
7.	Losses caused by delayed sale of stored wheat	93	77.5

Table 10 highlights further post-harvest losses experienced by respondents during the storage and transportation stages of wheat handling. A substantial 77.5% of respondents reported losses due to delayed sale of stored wheat, which appears to be a major challenge in managing stock efficiently. Grain losses caused by rodent attacks were also significant, affecting 70% of respondents, while 62.5% reported weight reduction in stored grain over time. In terms of storage conditions, 52.5% of respondents experienced fungal or mold losses, highlighting the importance of proper storage techniques and conditions. Grain losses due to insect infestations were reported by 29.17%, and rough road conditions during transportation led to losses for 39.17% of respondents. Spillage losses during transportation were also notable, with 39.17% reporting such issues. These findings point to the critical need for improved storage practices, pest control, better transportation infrastructure, and timely sale of stored grain to reduce these losses and improve overall post-harvest efficiency.

DISCUSSION

Demographic profile of respondents

The study found that all respondents were male, confirming that wheat farming and post-harvest activities in the study area are male-dominated. This aligns with the cultural context of many rural areas in Sindh, where men traditionally engage in field activities. Similar demographic patterns were reported by Chhachhar and Memon (2019), who found that agricultural decision-making and technology use in Sindh are primarily driven by male farmers, with cultural norms limiting women's participation in farming. The predominance of respondents aged 36–50 years (42.5%) and 20–35 years (27.5%) indicates a relatively active and potentially adaptable farming population. This is consistent with the findings of Chhachhar and Memon (2019), who noted that middle-aged farmers form the majority and are generally more receptive to adopting mobile technology, albeit constrained by infrastructural challenges. The age distribution suggests opportunities for capacity-building and technological adoption, as middle-aged and younger farmers are more likely to engage with training programs or new farming techniques. The majority being married (77.5%) implies

potential family support in farm labor but may also increase financial pressures, influencing decision-making and risk tolerance.

Education, family structure, and household size

Nearly half of the respondents (48.83%) had only completed primary education, with 15% having no formal education. This low literacy level can be a barrier to adopting improved farming practices, understanding extension materials, and accessing government programs. Ahmad et al. (2023) also found that education significantly influences smallholder farmers' capacity to understand and accept new agricultural approaches, with lower education levels acting as a constraint on adoption. Family structure shows a near even split between nuclear (55.83%) and joint families (44.17%), which may influence labor availability and resource pooling. Most households had 5–10 members (45%), providing a labor base for agricultural work but also increasing household consumption needs. These socioeconomic traits suggest the need for visual and practical training approaches and consideration of household labor dynamics in agricultural planning. Similar findings were observed by Chen et al. (2021), who emphasized that family labor availability and structure significantly affect farmers' access to productive agricultural services.

Land ownership, farm size, and experience

The high proportion of tenant farmers (51%) indicates a reliance on leased land, which can affect farmers' incentives to invest in long-term improvements like machinery or soil health. This is consistent with the findings of Saqib et al. (2025), who noted that land tenure insecurity among tenant farmers in Pakistan discourages long-term investments and hampers adoption of sustainable agricultural practices. Most farms were small to medium-sized (55% with 5–10 acres), limiting economies of scale and adoption of modern technology. Interestingly, 35.83% of farmers had over 11 years of experience, reflecting deep local knowledge, yet there remains a need for integrating traditional practices with modern methods. The coexistence of experienced farmers and newer entrants (19.17% with <5 years of experience) calls for tiered training programs to suit varying skill levels.

Cropping patterns

The dominance of mono-cropping (78.33%) in the area raises sustainability concerns. Continuous wheat cultivation without rotation can degrade soil fertility and increase pest and disease risks. Hammad et al. (2024) highlight that crop diversification is crucial for enhancing soil health, stabilizing yields, and promoting resilience in Pakistan's agriculture. However, policy gaps, lack of awareness, and insufficient extension services often limit diversification practices among smallholder farmers. The limited use of crop rotation (7.5%) or mixed cropping (17.33%) in the study area suggests a need for greater extension support and targeted incentives to encourage diversified cropping systems that improve both productivity and long-term sustainability.

Sources of Income

Agriculture was the primary income source for 55% of respondents, but a significant number relied on secondary sources such as daily wages (27.6%) and livestock (24.16%). This income diversification reflects economic vulnerability and the need for risk-spreading strategies. Iqbal et al. (2021) found that non-farm income diversification is a prevalent coping mechanism among agricultural households in Pakistan, driven by the instability of farm income and limited profitability in small-scale farming. It also

suggests that many farmers may not generate sufficient income solely from crop production, which could limit reinvestment into farming. Strengthening agricultural profitability through subsidies, value addition, and better market access may help reduce this dependency on secondary income. In this context, Khan et al. (2022) emphasized that enhancing farmers' access to mobile and internet technologies can significantly boost rural incomes by facilitating better information flow and market connectivity, offering pathways for more stable and diversified livelihoods.

Income and expenditure

The average household expenditure (PKR=57,795) exceeded the average primary income (PKR=40,508), implying that many farmers are under financial stress and rely heavily on secondary income or credit. This income-expenditure imbalance can hinder farmers' capacity to adopt improved technologies or withstand post-harvest losses. Kaur et al. (2024) observed similar trends in Punjab, where smallholder farmers struggled to match household expenses with farm income, often leading to borrowing and reduced savings. These findings highlight the need for targeted financial support programs, such as low-interest loans and income-stabilization mechanisms, to enhance the resilience of farming households and support long-term investment in agriculture.

Access to support and debt status

While 52.5% had received support from government or NGOs, nearly half had not. This points to gaps in outreach and accessibility of institutional support systems. Additionally, about 36% of respondents were in debt, which could further exacerbate their economic fragility. Kurma (2024) emphasized that access to agricultural credit plays a crucial role in shaping farmers' income and expenditure patterns, with insufficient institutional support often leading to greater dependence on informal borrowing and deepening financial stress. Expanding the reach of support programs and providing training in financial literacy could help farmers manage risks better and improve their productivity.

Issues in the wheat value chain

The most pressing issues included high costs of inputs (fertilizer, certified seed, and pesticides), lack of machinery, and inadequate training. These systemic problems reflect broader policy and infrastructure deficits. Agrawal and Jain (2024) highlight that inefficiencies in the wheat value chain from input procurement to post-harvest handling, are major constraints to productivity and farmer profitability. The finding that 74.17% of farmers lacked training reinforces the urgent need for targeted extension services. This aligns with findings by Grote et al. (2021), who noted that improving training and capacity building across wheat and maize value chains is crucial for food security in Asia. High input costs not only reduce profitability but may also result in suboptimal application, lowering yields and increasing vulnerability to pests and diseases. Brasesco et al. (2019) also emphasized the role of accessible inputs and mechanization support in strengthening wheat value chains in Africa, drawing parallels to similar gaps in South Asia. Moreover, as Assimakopoulos et al. (2024) suggest, integrating modern tools like AI and digital advisory systems could enhance decision-making and optimize input use, especially for resource-constrained farmers.

Post-harvest losses

Post-harvest losses were substantial, with 85% of respondents citing threshing machinery inefficiencies as the leading cause. Delayed harvesting (43.33%) and grain

shattering (50.83%) were also prominent. These losses reflect technical, managerial, and labor-related gaps. Gulati et al. (2024) identified similar bottlenecks in India, emphasizing that inadequate farmer-level interventions and inefficient grain handling are core contributors to post-harvest losses. Nath et al. (2024) further highlighted the need for advanced and accessible technologies to minimize quantitative and qualitative grain losses. Likewise, Kaur et al. (2025) stressed that poor post-harvest management practices particularly at the threshing and storage stages can drastically reduce both yield and grain quality. Additionally, Urugo et al. (2024) underscored that integrating agro-processing and training into local farming systems is essential for sustainable post-harvest loss reduction. Investment in improved and affordable post-harvest equipment, along with practical training in harvesting techniques, could therefore significantly reduce these avoidable losses.

Additional post-harvest losses

Rodent attacks (70%) and delayed sale of stored wheat (77.5%) were major contributors to storage losses, along with fungal infestations (52.5%) and weight reduction over time (62.5%). These issues point to inadequate storage infrastructure and poor market integration. Meneghetti et al. (2022) found similar challenges in Brazil, where rodent activity and environmental conditions during storage significantly affected wheat quality and quantity. Kumar et al. (2021) emphasized the importance of structured warehouse storage management in ensuring food security, noting that improper storage leads to both physical and nutritional losses in wheat. Nath et al. (2024) underscored the role of emerging technologies in mitigating grain storage losses, while Pasqualone (2025) advocated for upgrading traditional storage systems including underground and pit-based methods to modern, controlled-environment solutions. Strengthening storage facilities, introducing warehouse receipt systems, and improving road infrastructure can reduce losses and improve farm incomes.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study comprehensively examined the demographic characteristics, socio-economic conditions, and post-harvest loss dynamics among wheat farmers in District Shikarpur, Sindh. The findings revealed that wheat farming in the area is predominantly managed by middle-aged, married men with modest educational backgrounds, primarily operating small to medium-sized farms under tenancy arrangements. While agriculture remains the primary source of income, a significant portion of households also rely on secondary sources such as livestock and daily wages to meet their financial needs.

The study identified multiple challenges within the wheat value chain that contribute to substantial post-harvest losses. These include limited access to credit and certified inputs, high input costs, lack of modern machinery, inadequate farmer training, and inefficient harvesting and threshing practices. Notably, the inefficiency of threshing machinery (reported by 85% of respondents) emerged as the most critical factor contributing to grain loss. Additionally, poor storage conditions, pest infestations, rodent attacks, and delayed grain sales were significant causes of losses during the storage and transportation stages. Despite some respondents receiving support from government or NGOs, many farmers still face systemic barriers to adopting improved post-harvest practices. The findings underscore the urgent need for multi-faceted interventions, including enhanced access to inputs and credit, farmer capacity-

building, improved mechanization, infrastructure development, and market facilitation. Ultimately, reducing post-harvest losses will require coordinated efforts from relevant provincial departments in Sindh, alongside active participation from local farming communities. Addressing these challenges can significantly enhance wheat productivity, farmer income, and food security in the region.

RECOMMENDATIONS

Based on the findings of this study, the following six comprehensive recommendations are proposed to reduce post-harvest losses in the wheat value chain in district Shikarpur, Sindh:

- **Strengthen agricultural extension services and farmer training:** The Sindh Agriculture Extension Department should enhance its outreach programs by providing regular, field-based training to farmers on modern harvesting, post-harvest handling, input usage, and integrated pest management. Special attention should be given to improving awareness about storage practices and crop rotation to reduce long-term productivity losses.

- **Subsidize modern machinery and promote mechanization:** The Sindh Agriculture Engineering Department should provide subsidized or shared access to efficient threshing and harvesting machinery through farmer cooperatives or machinery banks. This will help reduce the 85% losses linked to inefficient threshers and minimize physical damage caused by manual or outdated equipment.

- **Improve input accessibility and credit support:** In collaboration with the Agriculture, Supply & Prices Department, GoS and Zarai Taraqiati Bank Limited (ZTBL), a targeted program should be launched to ensure timely access to quality seeds, fertilizers, and pesticides at affordable rates. This may include input vouchers, microcredit, and seasonal loan schemes for smallholder and tenant farmers.

- **Enhance storage facilities and promote safe grain handling:** The Sindh Food Department and Agricultural Research Institutes should work together to provide improved storage bags, community-level grain silos, and technical guidance on moisture control to prevent losses from rodents, fungi, and insects. Pilot projects can be introduced in high-loss zones for demonstration.

- **Upgrade rural infrastructure and transport facilities:** The Sindh Works & Services Department should prioritize maintenance and development of farm-to-market roads, especially in key wheat-producing areas. Better road connectivity will reduce grain spillage and physical damage during transport, addressing the 39.17% losses reported in this area.

- **Facilitate market access and timely grain sale:** The Sindh Agriculture Marketing Department should establish local market information centers and grain collection hubs to support timely sale and reduce dependency on middlemen. Introducing storage-linked credit and minimum support price enforcement will prevent losses associated with delayed selling, reported by 77.5% of farmers. By effectively involving these relevant departments, the recommended interventions can be successfully implemented, reducing post-harvest losses and improving the overall efficiency of the wheat value chain in District Shikarpur, Sindh.

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REFERENCES

Agrawal, M., & Jain, J. K. (2024). Seed to Sustenance: A Comprehensive Review of Wheat's Agricultural Value Chain. *Commerce Research Review, 1*(2), 84-93.

Ahmad, S., Xu, H., & Ekanayake, E. M. B. P. (2023). Socioeconomic determinants and perceptions of smallholder farmers towards agroforestry adoption in northern irrigated plain, Pakistan. *Land, 12*(4), 813.

APP, Associated Press of Pakistan. (2024). *Sindh produced 4.2 million tons wheat in crop season 2023-24*. https://www.app.com.pk/domestic/sindh-produced-4-2-million-tons-wheat-in-crop-season-2023-24

Assimakopoulos, F., Vassilakis, C., Margaris, D., Kotis, K., & Spiliotopoulos, D. (2024). Artificial intelligence tools for the agriculture value chain: Status and prospects. *Electronics, 13*(22), 4362.

Bartali, E. H., Boutfirass, M., Yigezu, Y. A., Niane, A. A., Boughlala, M., Belmakki, M., & Halila, H. (2022). Estimates of food losses and wastes at each node of the wheat value chain in Morocco: Implications on Food and energy security, natural resources, and greenhouse gas emissions. *Sustainability, 14(24),* 16561.

Brasesco, F., Asgedom, D., Sommacal, V., & Casari, G. (2019). *Strategic analysis and intervention plan for wheat and wheat products in the Agro-Commodities Procurement Zone of the pilot Integrated Agro-Industrial Park in Central-Eastern Oromia, Ethiopia*. Food and Agriculture Organization of the United Nations.

Chandio, A. A., Jiang, Y., & Rehman, A. (2018). Credit margin of investment in the agricultural sector and credit fungibility: The case of smallholders of district Shikarpur, Sindh, Pakistan. *Financial Innovation, 4*(27).

Chen, Z., Sarkar, A., Hossain, M. S., Li, X., & Xia, X. (2021). Household labour migration and farmers' access to productive agricultural services: A case study from Chinese provinces. *Agriculture, 11*(10), 976.

Chhachhar, A. R., & Memon, B. (2019). Challenges in usage of mobile phone regarding agricultural and marketing information among farmers in Sindh, Pakistan. *Indian Journal of Science and Technology, 12*(6), 1-9.

Chohan, A. A., Laghari, M., & Rajput, N. A. (2021). Harvest losses of wheat crop. *Journal of Quality Assurance in Agricultural Sciences*, *1*(01), 22-19.

FAO (2023). *Food Outlook – Biannual report on global food markets.* https://www.fao.org/3/cc3020en/cc3020en.pdf

GOP (2024a). *Agriculture: Economic Survey of Pakistan*, 2023-24, Ministry of Food and Agriculture, Government of Pakistan, Islamabad.

GoP (2024b). *7th Population and Housing Census*, 2024, Pakistan Bureau of Statistics, Government of Pakistan, Islamabad.

Grote, U., Fasse, A., Nguyen, T. T., & Erenstein, O. (2021). Food security and the dynamics of wheat and maize value chains in Africa and Asia. *Frontiers in Sustainable Food Systems, 4*, 617009.

Gulati, A., Das, R., & Winter-Nelson, A. (2024). *Reducing Post-Harvest Losses in Indian Agriculture-A Case Study of Selected Crops* (No. 20). Indian Council for Research on International Economic Relations (ICRIER), New Delhi, India.

Hammad, A., Ali, A., Mushtaq, K., & Kousar, R. (2024). Unveiling the dynamics of crop diversification in Punjab-Pakistan: Policy implications for sustainable agriculture. *Journal of Xi'an Shiyou University, Natural Science Edition, 20*(6), 366–385.

Iqbal, M. A., Rizwan, M., Abbas, A., Makhdum, M. S. A., Kousar, R., Nazam, M., & Nadeem, N. (2021). A quest for livelihood sustainability? Patterns, motives and determinants of non-farm income diversification among agricultural households in Punjab, Pakistan. *Sustainability, 13*(16), 9084.

Ismail, A. M., Raza, M. H., Zahra, N., Ahmad, R., Sajjad, Y., & Khan, S. A. (2024). Aflatoxins in Wheat Grains: Detection and Detoxification through Chemical, Physical, and Biological Means. *Life*, *14*(4), 535

Kaleri, A. A., Sadiq, M., Jamali, A., Ullah, Z., Musawwir, A., Islam, M., ... & Adil, S. (2024). Effects of Phosphorus Application Rate on the Growth and Yield of Wheat (Triticum Aestivum L.). *Pak-Euro Journal of Medical and Life Sciences*, *7*(2), 151-158.

Kaur, M., Saini, M. K., Samota, M. K., Purewal, S. S., & Swamy, C. T. (2025). Post-Harvest Management. *Colored Cereals: Properties, Processing, Health Benefits, and Industrial Uses*, 49.

Kaur, P., Singh, P., & Singh, J. M. (2024). Farm profitability under rising input costs in Punjab: Issues and concerns. *Journal of Agricultural Development and Policy, 19*(1), 90–98. https://doi.org/10.5958/2231-6736.2024.00015.2

Khan, N., Ray, R. L., Zhang, S., Osabuohien, E., & Ihtisham, M. (2022). Influence of mobile phone and internet technology on income of rural farmers: Evidence from Khyber Pakhtunkhwa Province, Pakistan. *Technology in Society, 68*, 101866.

Kumar, C., Ram, C. L., Jha, S. N., & Vishwakarma, R. K. (2021). Warehouse storage management of wheat and their role in food security. *Frontiers in Sustainable Food Systems, 5*, 675626.

Kumar, D., & Kalita, P. (2017). Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries. *Foods*, *6*(1), 8.

Kurma, M. V. (2024). Agriculture credit: Impact on income expenditure. *Anveshana's International Journal of Research in Regional Studies, Law, Social Sciences, Journalism and Management Practices,* 9(1).

Liu, L., Ross, H., & Ariyawardana, A. (2023). Building rural resilience through agri-food value chains and community interactions: A vegetable case study in wuhan, China. *Journal of Rural Studies, 101*, 103047

Manzoor, A., Maan, A. A., Khan, I. A., & Shahbaz, B. (2021). A Mixed-Method Study To Enhance Food Security By Reducing Post-Harvest Wheat Losses In Punjab, Pakistan. *Humanities*, 2, 87-99.

Meneghetti, V. L., Biduski, B., Tibola, C. S., Junior, A. L., de Miranda, M. Z., Lima, M. I., ... & Gutkoski, L. C. (2022). Evaluation of losses and quality maintenance of wheat during storage in a commercial unit in Brazil. *Journal of the Science of Food and Agriculture, 102*(4), 1569-1575.

Nath, B., Chen, G., O'Sullivan, C. M., & Zare, D. (2024). Research and technologies to reduce grain postharvest losses: a review. *Foods, 13*(12), 1875.

Nyaupane, S., Poudel, M. R., Panthi, B., Dhakal, A., Paudel, H., & Bhandari, R. (2024). Drought stress effect, tolerance, and management in wheat–a review. *Cogent Food & Agriculture*, *10*(1), 2296094.

Pakistan Bureau of Statistics. (2024). *Agriculture census*. Ministry of Planning, Development & Special Initiatives.

Pasqualone, A. (2025). Addressing Shortages with Storage: From Old Grain Pits to New Solutions for Underground Storage Systems. *Agriculture, 15*(3), 289.

Saqib, S. E., Yaseen, M., Ali, S., & Visetnoi, S. (2025). Agricultural Land Conversion and Challenges for Tenant Farmers: Empirical Evidence from Pakistan. *Land Degradation & Development, 36*(3), 802-815.

Sekaran, U., & Bougie, R. (2016). *Research Methods for Business: A Skill-Building Approach*. John Wiley & Sons.

Sikandar, M. A., Anjum, S., Idrees, A., Ali, H., Farooq, M. U., & Ismail, I. (2024). Economic analysis of wheat production in district Layyah Punjab, Pakistan. *Remittances Review,* 9(1), 2840-2855.

Statista. (2024). Global top wheat-producing countries in 2023/2024. *Statista*. *Retrieved* August 2, 2024. Global leading wheat producing countries 2023/2024 | Statista

United States Department of Agriculture (USDA). (2025). *Production, Supply, and Distribution (PS&D) Online: Wheat Statistics for Pakistan*. Retrieved March 11, 2025, from https://ipad.fas.usda.gov/countrysummary/Default.aspx

Urugo, M. M., Yohannis, E., Teka, T. A., Gemede, H. F., Tola, Y. B., Forsido, S. F., & Abdu, J. (2024). Addressing post-harvest losses through agro-processing for sustainable development in Ethiopia. *Journal of Agriculture and Food Research*, 101316.

Yin, R. K. (2017). *Case Study Research and Applications: Design and Methods*. Sage Publications.